A COMPARATIVE EVALUATION OF FLUORIDE RELEASE AND SHEAR BOND STRENGTH OF A POLYACID - MODIFIED COMPOSITE RESIN, A RESIN MODIFIED GLASS IONOMER CEMENT AND A CONVENTIONAL COMPOSITE RESIN

- An Invitro Study

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CERTIFICATE

*This is to certify that **Dr. SANGEETHA DURAISAMY**, post graduate student (2002-2005) in the Department of Orthodontics, Tamil Nadu Govt. Dental College & Hospital, Chennai-03 has done this dissertation titled "**A COMPARATIVE EVALUATION OF FLUORIDE RELEASE AND SHEAR BOND STRENGTH OF A POLYACID - MODIFIED COMPOSITE RESIN, A RESIN MODIFIED GLASS IONOMER CEMENT AND A CONVENTIONAL COMPOSITE RESIN - An Invitro Study**" under our direct guidance and supervision in partial fulfillment of the regulations laid down by the Tamilnadu Dr. M.G.R. Medical University, Chennai, for M.D.S., (Branch – V Orthodontics) Part - II degree examination.*

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INTRODUCTION

For the past 50 years, since the introduction of acid etching by Buonocore[21] in 1955 major improvements were achieved in bonding brackets to the teeth. The pioneering work of Buonocore, Bowen [17,18], Wilson[130] and Tavas[121] were instrumental in developing procedures and materials that have led to present day standards in orthodontic adhesives.

Buonocore advocated the use of phosphoric acid etching to improve the adhesion of acrylic resin filling materials to enamel as early as 1955.[59] This procedure involves dissolution of the organic component of the enamel matrix, creating microporosities in the enamel surface. Etching increases the wettability of the surface and facilitates the penetration of the resin into the enamel. A mechanical bond is formed between the resin adhesive and the tooth. In 1964 Newman[87] first bonded Orthodontic brackets to the teeth using the acid etch technique and an epoxy derived resin.

Bisphenol A glycidyl dimethacrylate, a diacrylate resin more commonly known as Bowen's resin or bis GMA, was patented in 1962[18]. This resin is an acrylic modified epoxy resin, combining the setting versatility of acrylic and the strength and dimensional stability of epoxy. The eventual addition of filler particles to these resins to form composites greatly enhanced the strength of this material[17,18].

Decalcification of enamel surface adjacent to orthodontic brackets is a common adverse effect of orthodontic treatment[53,56]. Increased plaque accumulation with concomitant bacterial acid production results in decalcification of the surrounding enamel. Patients often have difficulty in maintaining adequate oral hygiene with orthodontic appliances attached directly to the teeth. Estimates of the presence of white spot lesions per patient in orthodontically treated population range from 12.6 percent to 50 percent.[56]

This persistent problem has stimulated a search for a preventive procedure. Programs for prevention of decalcification or caries in the dental field are usually directed toward one or more of the following factors (1) alteration of the oral flora, (2) decrease in frequency and quality of fermentable carbohydrate intake, and (3) increase in resistance of the tooth surface to demineralization.[25]

Recently, studies have been concerned with the latter factor, by attempting to decrease the surface solubility. The benefits of fluoride in prevention of tooth decay and remineralization of decalcified enamel were described in the dental literature as early as 1942. The mechanism of fluoride reducing decalcification or caries is multifactorial. Fluoride increases the resistance of enamel to acid, increases the maturation rate of enamel, and interferes with the metabolism of microorganisms. Recent evidence shows that fluoride may facilitate the remineralization of white spot lesions. Fluoride ions encourage the formation of calcium fluoride and fluorapatite crystals. This reaction enhances remineralization of the etched enamel making it more resistant to demineralization[5, 90].

Patient compliance with self-administered fluoride delivery system is generally poor[126]. Attempts have been made to develop bonding agents that release fluoride. Such adhesives include glass ionomer cements, resin modified glass ionomer cements (RMGIC), and poly acid modified composite resins (PAMC)[126]. The potential advantage of a bracket bonding material with sustained release of fluoride is that a continuous release of fluoride would be possible adjacent to the bracket, the area of greatest risk for decalcification[31] .

Wilson and Kent introduced glass polyalkenoate, glass ionomer cements, to dentistry in 1972[130]. Glass ionomer cements bonds by carboxyl chelation to enamel, dentin, and most metals by employing various mixtures of carboxyl-containing acids with aluminosilicate glass. Aluminosilicate glass fused in the presence of fluoride fluxes results in an alkaline composition that releases fluoride ions when reacted with acids. Fluoride release has been measured during the GIC setting reaction and after setting. Additional fluoride is released when glass ionomer cements are exposed to acids. Caries inhibition has been associated with a sustained low level fluoride release from glass ionomer cements. Furthermore, glass ionomer cements contain hydrogel phases, supporting the movement of calcium, strontium, and other ions associated with the remineralization of enamel and dentin. GIC hydrogel phases are thought to be responsible for the uptake and re-release of added environmental fluoride from topical gels, rinses, and dentifrices [86]. Low fracture resistance limits their orthodontic use primarily to band cementation.

Tavas and Watts first described the use of visible light to cure composites used in orthodontic bonding in 1979[121]. In response to the demand for improvement in bond strength of the conventional glass ionomer cement, Antonucci et al introduced resin modified glass ionomer cements (RMGICs) in 1988[7].Addition of 10% to 20% resin monomers to the glass ionomer cements resulted in a cement that is initially hardened with the use of either light or chemical activators to polymerize the monomers. Resin modified glass ionomer cements are adhesive cements with improved physical properties and more stable hydrogels compared with glass ionomer cements. Polymerization of the resin monomers hastens the initial hardening of resin modified glass ionomer cements without interfering significantly with the acid-base setting reaction, the fluoride release, or the chelation of carboxyl groups to metal and tooth surfaces[86].

Polyacid-modified composite resins, also known as compomers, were developed to bring the features of caries inhibition and carboxyl chelation to resins. Compomers are single component systems consisting of aluminosilicate glass in the presence of carboxyl-modified resin monomers and light-activated conventional resin monomers. Although the alkaline glass and acidic carboxyl components are present in the same component, no acid-base setting reaction occurs because water is absent from the composition. However, after light-activation of the compomer, it is postulated that water sorbs into the compomer, allowing a delayed acid-base reaction that may release fluoride and other remineralizing ions from the aluminosilicate glass. The relatively weak acid-base reaction does not result in increased physical properties of the compomer. The absence of hydrogels restricts ion uptake and release, although fluoride recharging of compomers has been reported and can be explained by water sorption and diffusion dynamics[2,32,101,133]. Compomers have been linked to caries inhibition in vitro because of fluoride release from the aluminosilicate glass filler at low pH. Carboxyl chelation with cations on enamel, dentin, and metallic surfaces has not been shown to occur with compomer adhesives. Acid etching or other surface treatment and dry enamel surface are pre requisites for bonding with poly acid modified composite resins. Physical properties are acquired quickly as compomers polymerize, and their early setting strengths are superior to those of the resin modified glass ionomers but inferior to those of the resin adhesives[2].

A recently introduced bonding material Python light cure adhesive (TP orthodontics, LaPorte, Indiana) a polyacid modified composite resin[126] is marketed with manufacturer's claim of fluoride release and improved bond strength.

The purpose of this study is to evaluate the shear bond strength and the rate of fluoride release of the Python light cure material and to compare it with a resin modified Glass Ionomer cement, Fuji ortho LC (GC, Tokyo, Japan) and a non fluoridated orthodontic bonding material Transbond XT (3M Unitek, Monrovia, Calif).

AIMS AND OBJECTIVES

1. To evaluate the amount of **fluoride release** from a polyacid modified composite material (Python light cure adhesive,TP orthodontics, LaPorte, Indiana) stored in distilled water and artificial saliva using a **Fluoride ion specific combination electrode** and to compare it with a fluoride releasing control, resin modified glass ionomer cement (Fuji Ortho LC, GC, Tokyo, Japan) and a non fluoridated composite resin control (Transbond XT, 3M Unitek, Monrovia, Calif).

2. To evaluate the **shear bond strength** of the Python Light cure adhesive (TP orthodontics, LaPorte, Indiana) using the **Instron universal testing machine** and to compare it with the controls resin modified glass ionomer cement (Fuji Ortho LC, GC, Tokyo, Japan) and a non fluoridated composite resin control (Transbond XT, 3M Unitek, Monrovia, Calif).

3. To evaluate the **site of bond failure** and the amount of adhesive remaining on the debonded tooth surface **(Adhesive remnant index)** using **stereomicroscope.**

MATERIALS AND METHODS

I. ESTIMATION OF FLUORIDE RELEASE

MATERIALS

Adhesives Used

All the three materials used in this study were light-cured orthodontic bracket-bonding adhesives, two of them releasing fluoride**.**

Python light cure adhesive (TP Orthodontics, Inc., LaPorte, Ind).

This is a light-cured polyacid modified composite resin system releasing fluoride that is recommended for use to bond brackets on an uncontaminated etched enamel surface.

Transbond XT (3M Unitek, Monrovia, Calif).

This is a light-cured composite resin system that is recommended for use to bond brackets on an uncontaminated etched enamel surface.

Fuji Ortho LC (GC, Tokyo, Japan).

This is a light cured resin modified glass ionomer cement releasing fluoride recommended for use to bond brackets on an unetched enamel surface.

Preparation of adhesive disc samples

Twenty discs (6 mm in diameter and 2 mm in thickness) were fabricated from each material Python light cure adhesive, Transbond XT, and Fuji Ortho LC, using a split mold following manufacturer's instruction for curing. The surface area of the discs was calculated to be 0.9425 cm^2. After light curing, each polymerized specimen was released from the mold and placed into a polyethylene test tube. Half of the test tubes (10 per type of material) received 1 ml of distilled water, and the other half received 1 ml of artificial saliva. All test tubes were then capped, labeled, grouped and stored in an incubator at 37°C and 100% relative humidity.

Group A - Python light cure adhesive disc samples stored in 1ml of distilled water.

Group B - Python light cure adhesive disc samples stored in 1ml of artificial saliva.

Group C - Transbond XT light cure adhesive disc samples stored in 1ml of distilled water.

Group D - Transbond XT light cure adhesive disc samples stored in 1ml of artificial saliva.

Group E Fuji Ortho LC light cure adhesive disc samples stored in 1ml of distilled water,

Group F Fuji Ortho LC light cure adhesive disc samples stored in 1ml of artificial saliva.

Artificial saliva

The artificial saliva was made up according to a research based composition[34] and contained 1.04 g/L of KCl, 0.68 g/L of NaH_2PO_4, 0.42 g/L of $NaHCO_3$ 0.03 g/L of $CaCl_2$, and 0.01 g/L of $MgCl_2$.The pH of the artificial saliva was 6.95.

Fluoride ion-specific combination electrode

Measurements of fluoride released were taken with a fluoride ion-specific combination electrode (model EA 940; Orion Research Inc, Beverly, Mass). The electrode was calibrated with a series of standard fluoride solutions, ranging in concentration from 0.1 to 1000 ppm fluoride.

Total Ionic Strength Adjustment Buffer

Total Ionic Strength Adjustment Buffer TISAB III (Orion Research Inc.) is a commercial buffering solution designed to keep the pH between 5 and 5.5; it also frees F^- bound to hydrogen ions, eliminating interference from other ionic species such as hydroxyl and aluminium.

METHODS

Three ml of TISAB III (Orion Research Inc) was added to each ml of sample solution diluted to 30 ml, to obtain a constant background ionic strength and eliminate aluminium interference. Readings in mg/ lr were directly noted from the ion meter. Fluoride in 1ml of the sample (mg/lr) = ion meter reading (mg/lr) X dilution factor

The values in ppm were then converted to µg/cm 2 by dividing by the surface area of the discs.

1 ppm = 1mg / lr = 1µg /ml

Measurements of the fluoride levels and changing of the solutions were carried out daily for the first 7 days, end of every week for 3 weeks, and again at the end of first month using the Fluoride ion-specific combination electrode.

One day before each weekly and monthly fluoride assays, the specimens were washed and transferred into 1 ml of fresh solution, to avoid cumulative effects, and 24 hours later fluoride release data were gathered for the different time intervals.

Statistical Analysis

Descriptive statistics, including the mean, standard deviation, were calculated for each of the six groups of the samples tested. ANOVA, Tuckey – HSD and Student's t test were used to determine the statistical significance of difference between mean fluoride release of each group with categorical variations being the type of material, type of storage media and time of estimation.

II. ESTIMATION OF SHEAR BOND STRENGTH.

MATERIALS

Teeth samples

Hundred and twenty human premolars extracted for orthodontic treatment purpose were collected, cleaned of debris and stored in distilled water. The water was changed weekly to avoid bacterial growth. The criteria for tooth selection included, intact buccal enamel, with no hypoplastic spots, caries or cracks due to the pressure of the extraction forceps, and not subjected to any pretreatment chemical agents, such as alcohol, formalin, hydrogen peroxide.

Adhesives Used

Three different types of adhesive systems were evaluated in the current study, Python light cure adhesive (TP Orthodontics, Inc., LaPorte, Ind), a light-cured polyacid modified composite resin system releasing fluoride that is recommended for use to bond brackets on an uncontaminated etched enamel surface.

Transbond (3M Unitek, Monrovia, Calif), a light-cured composite resin system that is recommended for use to bond brackets on an uncontaminated etched enamel surface.

Fuji Ortho LC (GC, Tokyo, Japan).

This is a light cured resin modified glass ionomer cement releasing fluoride recommended for use to bond brackets on an unetched enamel surface.

Brackets

Hundred and twenty, Gemini Series (3M Unitek, Monrovia, Calif.), Roth prescription 0.022" slot, premolar metal brackets with an average bracket base surface area of 10.61 mm^2 were used in this study.

Instron universal testing instrument

Instron universal testing instrument, (Model 1195, Instron Corp., Canton, Mass.) which was calibrated to a full-scale compression load range of 0.1KN to 100KN was used in this study to determine the shear bond strength. The Instron machine has a lower vise to which the testing samples can be secured and a upper crosshead which can move either upwards or downwards with variable speed, to which a chisel with sharp edge can be connected to produce the shearing force for debonding the brackets in shear bond strength testing. The force applied to debond the bracket was recorded with a pen on the x-y recorder connected to the Instron machine, with force recorded on the y-axis and time on the x-axis. The highest point on the graph is the bond strength of the adhesive in kilograms.

Stereomicroscope

Stereomicroscope (stereozoom microscope, Carl zeiss, Germany), a light optical microscope with a magnification range of 5X to 50X and an inbuilt camera was used to asses the site of bond failure and amount of adhesive remaining on the enamel surface after debonding.

METHODS

Experimental Groups

The hundred and twenty premolars were separated randomly into six groups of twenty each. All teeth were embedded in self-cure acrylic blocks of cuboid shape up to the level of the cementoenamel junction. . The acrylic blocks were made from standardized molds and fashioned to fit the Instron universal testing machine. Each tooth was oriented such that the buccal surface is perpendicular with the bottom of the mold, with the long axis of the crown parallel to the central axis of the acrylic block and when oriented with the testing device the buccal surface will be parallel to the force during the shear strength test. The acrylic blocks were colour coded for easy identification of the different groups.

Group I.: (blue colour blocks) Brackets to be bonded using Python light cure adhesive. Bond strengths to be tested 30 minutes after bonding, after completion of initial polymerization.

Group II: (yellow colour blocks) Brackets to be bonded using Python light cure adhesive. Bond strength s to be tested 24 hours after bonding, after completion of final polymerization.

Group III: (light pink colour blocks) Brackets to be bonded using Transbond XT adhesive. Bond strengths to be tested 30 minutes after bonding, after completion of initial polymerization.

Group IV:(dark pink colour blocks) Brackets to be bonded using Transbond XT adhesive. Bond strength s to be tested 24 hours after bonding, after completion of final polymerization.

Group V: (green colour blocks) Brackets to be bonded using Fuji Ortho LC adhesive. Bond strength to be tested 30 minutes after bonding, after the completion of initial polymerization.

Group VI: (clear acrylic blocks) Brackets to be bonded using Fuji Ortho LC adhesive. Bond strength to be tested 24 hours after bonding after completion of final polymerization.

Groups I and II represented the new polyacid modified composite resin material releasing fluoride. Whereas groups III through VI were control groups, representative of the conventional light-cured resin adhesive systems and a resin modified glass ionomer cement.

Bonding Procedure

The teeth were cleaned and then polished with a non-fluoridated oil free pumice paste and rotating rubber prophylactic cup in a slow-speed hand piece for 10 seconds. The teeth were then rinsed with a water spray and dried with a blast of air from oil-free air source.

Python light cure adhesive was used to bond the brackets to group I and II teeth samples. Bonding procedures were performed according to the manufacturer's instructions. Python light cure adhesive system consisted of an enamel conditioner, a resin sealant and a bonding paste. The enamel conditioner was applied to the buccal surface of each tooth for 35 seconds. The teeth were then rinsed with a water spray for 30 seconds and dried with an oil and moisture free air source for 20 seconds. The buccal surfaces of the treated teeth appeared chalky white in color. A thin coat of the resin sealant was applied to the enamel surface and to the bracket base. The bonding paste was placed and spread on the bracket base with a spatula. The bracket was then firmly placed on the tooth. Any excess paste around the bracket base was removed with an explorer. The brackets were exposed to the light source for 30 seconds with 15 seconds each on mesial and distal side of the bracket, approximately 5mm above the interproximal contact area using a Hilux curing unit (Heraeus kulzer, Germany).

Transbond XT orthodontic bonding system was used to bond the brackets to group III and IV teeth samples. Bonding procedures were performed according to the manufacturer's instructions. A 35% phosphoric acid gel (Transbond XT etching gel) was applied to the buccal surface of each tooth for 15 seconds. The teeth were then rinsed with a water spray for 30 seconds and dried with an oil and moisture free air source for 20 seconds. The buccal surfaces of the etched teeth appeared chalky white in color. The light-cured orthodontic adhesive Transbond XT adhesive system used in this study consisted of an orthodontic bonding paste and an enamel bond sealing resin. After the etching procedure, a thin coat of the resin sealant was applied to the enamel surface, whereas the bonding paste was placed and spread on the bracket base with a spatula. The bracket was then firmly placed on the tooth. Any excess paste around the bracket base was removed with an explorer. The brackets were exposed to the light source for 20 seconds with 10 seconds each on mesial and distal side of the bracket, approximately 5mm above the interproximal contact area using a Hilux curing unit (Heraeus kulzer, Germany).

Fuji Ortho light cure adhesive was used to bond the brackets to group V and VI teeth samples. Bonding procedures were performed according to the manufacturer's instructions. Powder and Liquid were dispensed in the standard powder to liquid ratio of 3.0g/1.0ml. The powder was divided into 2 equal parts and the first portion was mixed with the liquid for 10 seconds. Then the remaining powder was mixed thoroughly for an additional 15 seconds. The mix was placed and spread on the bracket base with a spatula. The tooth surface to be bonded was wiped with a moist cotton pellet because a desiccated enamel surface will adversely affect the bond strength. The bracket was then firmly placed on the tooth. Any excess paste around the bracket base was removed with an explorer. The brackets were exposed to the light source for 40 seconds with 10 seconds each on mesial, distal, occlusal and gingival aspect of the bracket, using a Hilux curing unit (Heraeus kulzer, Germany).

The specimens were stored in an incubator at 100% relative humidity and

37°C until testing. At the end of 30 minutes, group I, III and group V samples were subjected to shear strength analysis on an Instron machine. Group II, IV and group VI samples were subjected to shear strength analysis after 24 hours.

Shear bond strength testing

Each sample was subjected to shear bond strength testing on an Instron universal testing machine. The acrylic block was secured in the lower vise of the Instron with the surface of the bracket base parallel to the line of force. A chisel was connected to the upper crosshead of the Instron such that its sharp edge can be placed between the bracket base and enamel and a shearing load can be applied on the enamel bracket interface when the upper crosshead moves downwards.

An occlusogingival load was applied to the bracket producing a shear force with a 50KN load cell and a crosshead speed of 1 mm/minute until shearing of the bracket from the tooth occurred. The shearing force required was recorded on the x-y recorder with force recorded on the y-axis with a scale of 20 kg and time on the x-axis. The highest point on the graph is the bond strength recorded in kilograms. The values are converted to newtons and then to megapascals using the surface area of the bracket base and recorded.

$$1 \text{ kg} = 9.81 \text{ newtons}$$

$$1\text{Mpa} = 1\text{newton} / \text{mm}^2$$

$$\text{Shear bond strength (Mpa)} = \frac{\text{dislodging force in newtons}}{\text{Bracket base area in mm}^2}$$

Adhesive Remnant Index

After debonding, the teeth were rinsed and dried using an air water syringe. No attempt was made to remove any remaining adhesive until the teeth were subjected to Adhesive Remnant Index assessment. All the 120 samples were examined with a stereomicroscope under 20X magnification to evaluate the site of bond failure and the presence of residual adhesive. Any adhesive remaining after removal of the bracket was assessed according to the Adhesive Remnant Index (ARI) as given by Artun and Bergland, and scored on a scale of 0 = No adhesive left on the tooth, 1 = Less than half of the adhesive remaining on the tooth surface, 2 = More than half of the adhesive remaining on the tooth surface, 3 = All of the adhesive remaining on the tooth surface, showing the impression of the bracket base.

Statistical Analysis

Descriptive statistics, including the mean, standard deviation, and minimum and maximum values, were calculated for each of the six groups of teeth tested. The analysis of variance was used to determine whether significant differences existed between groups I, III, & V and groups II, IV & VI. A Tukey test was used to determine which, if any of, the means were significantly different from each other. Student independent t test was done to determine if the mean bond strength of same material at different setting time were significantly different from each other. The bond strength data were subjected to a Weibull analysis to predict the probability of failure of the bracket bonding system at any level of shear stress. Chi-squared test was used to determine the ARI score and the different study group. Spearmen rank correlation analysis was used to find the association between the bond strength and the ARI score.

REVIEW OF LITERATURE

New orthodontic adhesive resins and hybrid composite resins offer improved physical properties like greater bond strength and clinical benefits like release of fluoride and prevention of enamel decalcification due to plaque accumulation around orthodontic appliances. This review of literature was made as an attempt to highlight the physical properties, chemical characters and clinical performance of composite resin bonding adhesives, Glass ionomer bonding adhesives, resin modified glass ionomers and polyacid modified composite resin with emphasis on their fluoride releasing property and shear bond strength.

Buonocore M.G (1955)[21'59] introduced the bonding technique in the field of dentistry. He demonstrated that pretreatment of enamel surface with orthophosphoric acid increased the surface area of enamel and produced mechanical inter locking of resin to enamel. He employed a phosphoric acid and phosphomolybdate oxalic acid treatment to alter enamel surface chemically and concluded that phosphoric acid treatment gave better results.

Bowen R.L. (1962)[17,18] explored the possibility of using epoxy resins (diglycidyl ether of bisphenol A) mixed with silica particles. The in vitro results were promising, but the presence of moisture inhibited the polymerization process of the epoxy resin. To overcome this problem, Bowen attached methyl methacrylate groups to the groups of the epoxy resin, thereby converting the epoxy resin to a dimethacrylate. The experimental outcome was successful and resulted in new resin called Bisphenol A glycidyl methacrylate, or BIS-GMA, or Bowen's resin.

Newman G.V. (1965)[87] introduced the direct bonding technique by combining acid etching with epoxy resin for bonding orthodontic brackets.

Balenseifen JW, Madonia JV. (1970)[13] stated that fixed orthodontic appliances retains plaque ,makes oral hygiene maintenance difficult and are responsible for further demineralization reactions.

Gwinnett AJ, Buonocore MG, Sheykholeslam Z. (1972)[58] suggested that topical fluoride applications fill in the interprismatic spaces produced by acid etching and may act as a physical barrier and thus reduce the bonding capacity of the adhesives.

Sheykholeslam and associates (1972)[111] reported that topical application of sodium fluoride (NaF), stannous fluoride (SnF_2), titanium tetrafluoride (TiF_4), and zirconium tetrafluoride (ZrF_4) after acid etching decreased the tensile bond strength of a methyl methacrylate resin.

Miura et al (1973)[84] measured shear bond strengths of plastic brackets bonded with methyl methacrylate and a silane coupling agent after various surface preparation procedure. SEM studies showed pumice prophylaxis before acid treatment removes the organic material such as acquired pellicle, from the enamel surface which has been hypothesized to inhibit optimum etching from occurring.

Kochavi D, Gedalia I, Anaise J. (1975)[71] evaluated the effect of conditioning with fluoride and phosphoric acid on enamel surfaces by scanning electron microscopy and concluded that topical fluoride treatments could cause significant reductions in bond strength.

Reynolds (1975)[106] suggested that minimum bond strength of 6-8 Mpa would appear to be adequate for most clinical orthodontic needs. He also reported successful clinical bonding with adhesives that provide invitro bond strength of approximately 5 Mpa.

Jeansonne BG, Feagin FF. (1979)[66] showed that fluoride was more effective in inhibiting demineralization of the enamel than increasing remineralization of lesions, supporting the in vitro observation that low levels of fluoride in acidic buffer solutions decrease the solubility of the enamel considerably.

Ceen, and Gwinnett, (1980)[23] conducted a study to determine the thickness of polymerized sealant at the vulnerable bracket resin periphery using six commercially available bonding materials and the results show a wide range of sealant thickness from 0-228 um and concluded that this resin films with their low abrasion resistance cannot be expected to provide long standing protection against demineralization.

Hirce JD et al (1980)[60] have found that application of basic phosphate fluoride or 8% stannous fluoride did not alter the bond strength of the resin adhesive.

Gorelick, Geiger, and Gwinnett(1982)[56] studied the incidence and severity of white spots after a full term of orthodontic treatment among patients in the separate private practices of two of the authors. Results showed that 50 percent of the patients experienced an increase in white spots. 10 per cent of the teeth had white spots in the treatment group compared to 2.5 per cent in the control group. Certain teeth and tooth surfaces exhibit a predisposition to white spot formation. Access to the flow of saliva and the distance from bracket to free gingival margin are factors affecting formation of white spot lesions. They also concluded that teeth banded or bonded for a relatively short treatment interval (from 12 to 16 months) showed the same incidence of white spots as those involved in longer treatment (as long as 36 months).

Mellberg JR, Mallon DE. (1984)[82] following an in vitro study stated that sodium mono fluoro phosphate and sodium fluoride accelerated remineralization of small decalcified or carious lesions and also reduced the formation of new lesions by incorporation of fluoride into the enamel structure as fluorapatite [$Ca_5(PO4)3_F$]

Artun.J, Bergland.S. (1984)[10] compared the bond strength of conventional resin after conditioning the enamel surface with 37% phosphoric acid and crystal growth conditioning with polyacrylic acid and found that polyacrylic acid has less bond strength. They used an Adhesive Remnant Index (ARI) system to evaluate the amount of adhesive left on the tooth after debracketing. This index system was developed on the basis of a pilot study on twenty extracted teeth, and the criteria are as follows: a score of

0 = No adhesive left on the tooth,

1 = Less than half of the adhesive remaining on the tooth surface,

2 = More than half of the adhesive remaining on the tooth surface,

3 = the entire adhesive remaining on the tooth surface, showing the impression of the bracket base.

Read M.J.F (1984)[105] described about the bonding of orthodontic attachments using a visible light cured, urethane dimethacrylate resin. He mentioned that the light cured resin has generous working time and on command set, which makes removal of excess material easy. The homogenous consistency of the composite remains constant over a long period of time and this makes handling more predictable.

Barkmeier, Gwinnett, and Shaffer, (1985)[14] conducted an in vitro study to evaluate the bond strength of brackets using 50% phosphoric acid for 15 and 60 seconds and to evaluate the enamel morphology after etching. Results showed no statistically significant differences in the bond strength and no qualitative differences were observed in surface morphology of the etched site.

Evans and Powers (1985)[42] studied the bond strength of no mix orthodontic cements and recommended the minimal and uniform thickness of resin cement for maximal strength for bonding. They stated that bond strength decreases as thickness increases, because of a greater amount of thermal expansion, polymerization shrinkage, trapped volatiles, and imperfections (voids and cracks) When one-step or no-mix cements were used, the depth of cure at the primer-paste interface was also found to be an important factor as thickness was increased.

Norris et al (1986)[89] evaluated the retentive bond strengths of orthodontic bands cemented with two new fluoride-releasing cements, a zinc polycarboxylate and a glass ionomer, and compared them with the retentive bond strength of bands cemented with the standard orthodontic cement zinc phosphate. They also evaluated the site of cement failure. They concluded that under the test conditions, both the zinc polycarboxylate and glass ionomer cements tested are as effective as the standard orthodontic luting cement, zinc phosphate, in retaining bands. They stated that the favourable failure site of the glass ionomer cement may offer clinical protection against decalcification under loose orthodontic bands. The adequate working time of the glass ionomer cement is equivalent to that of the zinc phosphate; however, the short working time of the zinc polycarboxylate cement may preclude its routine orthodontic use.

White (1986)[128] described a method of bonding orthodontic brackets to the enamel surfaces of teeth with glass ionomer cement. He emphasized the necessity for drying the teeth with cotton rolls and isolating the newly bonded brackets from mouth moisture during the early stage of glass ionomer setting. White also stated that the glass ionomers used in his evaluation were not as strong as composite resins. The article stressed the need to avoid early saliva contamination and to use only very light arch wires immediately after the bonding procedure, because the material did not achieve full strength for at least 24 hours.

Reilly and Featherstone (1987)[90] conducted a study to investigate the amount and extent of demineralization occurring around bonded orthodontic appliances after one month in vivo and the ability of commercially available fluoride products to inhibit and/or reverse such orthodontically related demineralization. He concluded that rapid demineralization occurs around the orthodontic appliances as early as one month, even with the use of a proven fluoride dentifrice. He also stressed the importance of use of additional preventive measure against orthodontically related decay.

Geiger AM et al (1988).[53] In a clinical study to evaluate the effect of fluoride program on white spot formation concluded that despite efforts to educate patients and parents, poor compliance with a preventive fluoride rinse program occurred in 50% of patients.

Øgaard, Rølla, Arends, Ten Cate (1988)[96] performed clinical experiments to investigate the effect of fluoride on carious lesion development and on lesions established during fixed orthodontic therapy. They stated that all presently available fluoride agents are developed from the concept of fluoridating the enamel in the form of fluorhydroxyapatite but research has indicated, that calcium fluoride formation may be a major aspect of the mechanism of the cariostatic effect of topical fluoride. Therefore they compared a fluoride solution with very low pH (1.9) that induced large amounts of calcium fluoride with a 0.2% solution of sodium fluoride (NaF). They found that daily fluoride mouth rinsing with a 0.2% solution of sodium fluoride (NaF) retarded lesion development significantly, whereas the fluoride solution with low pH inhibited lesion formation completely.

Øgaard, Rølla, Arends (1988)[94] conducted experiment to investigate carious lesion development associated with fixed orthodontic therapy. Visible white spot lesions were seen within 4 weeks in the absence of any fluoride supplementation. Both micro radiographic and SEM examinations showed surface softening of the enamel surface. They concluded that the enamel demineralization associated with fixed orthodontic therapy is an extremely rapid process caused by a high and continuous cariogenic challenge in the plaque developed around brackets and underneath ill-fitting bands and recommended careful inspection of the appliance at every visit and preventive fluoride programs are therefore required.

Greenlaw R, Way DC, Khadry AG. (1989)[57] stated that although the in vitro shear bond strength of visible light cure is only one half that of the chemically cured resin, the visible light-cured resin can be used clinically with good results and the enamel loss with visible light cure was also less during debonding procedure.

Artun and Thylstrup (1989)[11] conducted a three year clinical and SEM study of surface changes of carious enamel lesions after debonding of orthodontic appliances. They confirmed that surface wear rather than repair causes the clinical improvement in arrested white spot lesions and fluorides alone cannot prevent caries development if the status of the cariogenic challenge is preserved. It is therefore equally important to concentrate on hygiene measures combined with regular professional plaque removal.

Klockowski, Davis, et al (1989)[70] evaluated the bond strength and durability of three glass ionomer cements when used as a bonding agent and compared it with a composite resin-bonding agent and concluded that the bond strength of the glass ionomer cements are significantly less than the composite resin and the bond strengths of the glass ionomers were not greatly affected by thermocycling and majority of failures involved cohesion within cement or adhesion involving the enamel.

Ogaard B. (1989)[95] studied the prevalence of white spot lesions in 19-year-olds subjected to and not subjected to orthodontic treatment. Fifty-one orthodontic patients at an average of 5.7 years since orthodontic appliances were removed and 47 untreated subjects were examined. The median white spot score was significantly higher in the orthodontic group than in the untreated group. The orthodontically treated subjects also had more teeth with white spot lesions than the untreated subjects. The highest prevalence was noted on the first molars in both groups. In the orthodontic group the mandibular canines and premolars and the maxillary lateral incisors were also affected. The present study showed that white spot lesions after orthodontic treatment with fixed appliances may present an esthetic problem, even more than 5 years after treatment

Sonis. A. and Snell (1989)[5] conducted a study to compare a visible light-activated, fluoride-releasing bonding system with a visible light-activated conventional bonding system relative to bracket retention and prevalence of decalcification in twenty-two patients with 206 experimental brackets and 206 control brackets over an average treatment period of 25 months and concluded that a visible light-activated, fluoride-releasing bonding system is capable of adequately retaining brackets while aiding in the prevention of decalcification around bonded appliances

O'Brien, Read et al., (1989)[91] evaluated the clinical performance of visible light-cured material compared to a chemically cured adhesive. They concluded that visible light-cured adhesive was a satisfactory alternative to conventional chemical cured materials. The handling properties of the light-cured materials were found to be superior to the chemically cured materials.

Underwood and colleagues (1989)[123] stated that incorporation of inorganic fluorides into dental resins creates problems of phase separation and loss of mechanical integrity because of the highly polar nature of the fluoride salts and low polarity of dental resins. Organic fluoride incorporation has a plasticizing effect that also yields poor properties. He conducted a study to examine the clinical durability and caries inhibition potential of a fluoride-exchanging resin when used as an orthodontic bracket-bonding adhesive and to compare it with a non fluoride releasing adhesive. This fluoride-releasing resin is unique in that the fluoride ion is incorporated as a mobile ion charge in an anion-exchanging resin. This resin has a three-dimensional, highly crossed-linked network with fixed positive charges and fluoride counter charges. Fluoride release occurs when fluoride ions are exchanged for other anions in the oral environment. Rather than supplying fluoride to the oral environment by material dissolution, the fluoride is given up in exchange for other anions and the structure integrity of the resin is maintained. Long-term low-level fluoride release is possible without reduction in necessary physical characteristics. They demonstrated a 93% reduction of occurrence of dark zone (2% to 4% enamel porosity) formation around brackets when compared with a control adhesive, indicating a significant reduction in the first stages of enamel alteration. They concluded that the sustained low-level release of fluoride ions from the fluoride-exchanging adhesive reduced the formation and progression of very early demineralization of enamel surrounding orthodontic appliances and occurrence of adhesive rather than cohesive failure indicated that structural integrity was maintained for both adhesives. Success and failure rates of both adhesives indicated similar durability characteristics.

Cook P.A. (1990) [28]Compared the vivo bond strength of glass ionomer cement with a composite resin-bonding agent. The results of his evaluation indicated that the bond strength of the glass ionomer was not nearly as good as that of the composite resin. Cook stated that thorough drying of the teeth before glass ionomer use was not necessary but that cotton rolls should be used to isolate the field of operation. He also concluded that glass ionomer bonded relatively better to the bracket than to the enamel; its fractures tended to be cohesive failures, within the cement itself.

El Mallakh BF, Sarkar NK. (1990)[40] evaluated the fluoride release from glass-ionomer cements in de-ionized water and artificial saliva and concluded that the fluoride release from material into distilled water is significantly greater than that into artificial saliva

Fajen et al. (1990)[43] evaluated the bond strength of three glass ionomer cements against a composite resin in vitro, and found the bond strength of the glass ionomers to be significantly less.

Fox NA. (1990)[47]Stated that the low-dose fluoride continually released exactly where it is needed may, however, be more important in the prevention of decalcification through fluorapatite formation than single high doses of fluoride

Joseph and Rossouw (1990)[124] **s**tated that fully polymerized, fissure sealants could be used to seal the complete buccal enamel, thus preventing the possibility of immediate or future decalcification around orthodontic brackets. They also determined the shear bond strengths of stainless steel orthodontic brackets bonded to teeth with an orthodontic bonding resin together with a primary coating of various fissure sealants (a light-cured unfilled clear fissure sealant, a light-cured microfilled fissure sealant, and a chemically cured opaque fissure sealant.) and evaluated the fracture sites of these debonded samples. This study demonstrated that a fissure sealant resin can be applied to seal the buccal surface of a tooth and have a bracket bonded to it, which exhibits shear bond strengths that are equal to, if not higher than, the standard method of bonding, and the fracture sites of the fissure-sealed teeth are located more at the resin/enamel interface than those of teeth without sealant, thus leaving less cleaning of the tooth surface after debonding.

Fox NA, McCabe JF, (1991)[46] compared the shear bond strength of a conventional composite resin with that of a fluoride releasing composite and a glass ionomer cement. The results obtained showed that the conventional composite resin had the highest mean bond strength. The results were analyzed using the weibull analysis, which examines bond reliability rather than mean bond strength. They concluded that the bond reliability of the conventional composite resin and fluoride releasing composite resin are comparable and both of them will behave in a similar manner in the clinical situation.

McCourt et al (1991) [76]conducted a study to evaluate the bond strength of two light cured fluoride-releasing materials, a urethane dimethacrylate with sodium fluoride (time Line) and a glass ionomer-linked methyl methacrylate (Vitra bond) when used as an orthodontic bracket adhesive and compared them with a non-fluoride-releasing light-cured composite resin bonding material (Transbond). They concluded that the two fluoride-releasing, light-cured materials tested have low bond strengths after 30 days and are not acceptable as orthodontic bracket bonding agents. They recommended a modified bracket bond method in which a thin layer of fluoride-releasing low-viscosity material is placed around the brackets already bonded in patients with a high caries risk or poor oral hygiene habits.

Rezk-Lega et al. (1991)[107] conducted an in vitro study of glass ionomers versus composite resin bonding agents and concluded that glass ionomer cements have significantly less bond strength than composite resin in vitro.

Bjorn Ogaard, felipe Rezk – Lega et al (1992)[93] designed a study to investigate the cariostatic potential in vivo of an visible light curing adhesive for the bonding, of orthodontic brackets and found that the fluoride adhesive reduced lesion depths by 48% than the non fluoride adhesive and it was concluded that the regular use of tooth paste was insufficient to inhibit lesion development around orthodontic brackets.

Compton et al. (1992)[26] compared the bond strength of glass ionomer cements, emphatically stating that they must not be contaminated by moisture during the bonding procedures. In addition, they suggested, conditioning the tooth bond sites with a weak acid to enhance the cohesive strength.

Eliades et al (1992)[41] explained two basic concepts adopted in the design of fluoride-releasing composite resins: the incorporation of fluoride in a dispersed phase, which is released by dissolution and the synthesis of fluoride-releasing resins in which fluoride is given by an ion-exchange mechanism and stated that these approaches demonstrated the problems associated with the rate of fluoride release and with the solubility of the polymer network. He evaluated the extent of fluoride uptake from enamel bonded to an experimental visible light-cured orthodontic adhesive based on a new fluoride releasing system, based on ytterbium trifluoride filler (YbF_3) in an invivo study using a combined wavelength-energy dispersive electron probe microanalysis to study the enamel-adhesive interfaces and concluded that the cumulative fluoride uptake by enamel from the experimental adhesive was not statistically different from the fluoride detected in the control groups

Fricker (1992)[50] conducted a twelve month clinical trial of a glass ionomer cement for the direct bonding of orthodontic brackets compared with a standard composite bonding adhesive. This study shows a significant difference in failure rates of orthodontic brackets cemented with a thick mix of glass ionomer (20%) compared with composite bonding resin (5%). He concluded that glass ionomer cement, when used as a thick mix, has a poor clinical performance than composite resin for the direct bonding of orthodontic brackets. The leach of fluoride by glass ionomer cement prevents enamel demineralization around bracket margins and is a definite advantage and these cements should be reserved as bracket adhesives for patients who have poor oral hygiene and high caries rate.

Tanbirojn D et al (1992)[120] reported that with a F release of as little as 0.2 μgF-/cm2, a F uptake in the outer 10 μm of enamel, after 24 hours contact, of as high as 5400 ppm occurs.

McKnight-Hannes C, Whitford GM. (1992)[78] in a study estimating the the fluoride release from three glass-ionomer materials and the effect of varnishing with or without finishing stated that the rate of fluoride release from a material is affected by several factors such as temperature, mechanical shaking, frequency of analysis as well as the medium in which the samples are stored.

Aasrum E, Nganga PM, Dahm S, Ogaard B. (1993)[1] compared the tensile bond strength of a fluoride releasing light cure adhesive with two light cure adhesives and concluded that the fluoride-releasing light-curing adhesives for bonding brackets gave tensile bond strength adequate for orthodontic purposes. The bond strength did not change during a 6-month period when fluoride was released from the material and such a fluoride-releasing adhesive may be of clinical interest to inhibit white spot lesions around brackets.

Axel Voss, Reinhard Hickel, Stefan Mölkner (1993)[12] conducted a study to measure in vivo the bonding properties of conventional mesh-backed brackets bonded with GIC, and he also evaluated a new experimental bracket base designed to improve bond strength with GIC. The results of this study showed that GIC is suitable for use as a bonding material for orthodontic attachments providing bond strength that can be improved by developing modified bases.

Boyd RL (1993)[19] while comparing three self-applied topical fluoride preparations for control of decalcification in orthodontic patients found that significant decalcification occur in patients, even when they had received comprehensive initial tooth brushing instructions, used a standard sodium fluoride dentifrice and received monthly follow-up instructions and reinforcement in tooth brushing.

Dubroc, Mayo, and Rankine (1994)[38] examined the ability of a fluoride-releasing resin to reduce caries, as well as demineralization around orthodontic brackets, by using the Sprague-Dawley rat as a model. The results of this study suggest that in the rat model a fluoride-releasing orthodontic adhesive has the capacity to reduce the extent of decalcification in the immediate vicinity of plaque retentive orthodontic brackets and reduce incidence of caries at sites distant from the point of application, by serving as a source for controlled release of fluoride throughout the oral cavity.

Fox NA, McCabe JF, (1994)[48] reviewed a large number of publications on evaluation of invitro bond strength of orthodontic adhesive materials and revealed a large variation in the methods used for bond strength testing, making comparison of papers difficult and often impossible. They made the following suggestions in order to provide a protocol for future bond strength testing in orthodontics. Surface premolar enamel should be used on teeth extracted from adolescent patients for the orthodontic reasons. Teeth should be used after 1 month and before 6 months from extraction and should be stored in distilled water prior to bonding. After bonding, the specimen should be immersed in water for 24 hours at 37ºc. Debonding should take place on an instron or equivalent universal testing machine at a crosshead speed of 0.1mm per minute. Care should be taken to ensure that the point of application and direction of debonding force is the same for all specimens. At least 20 and preferably 30 specimens must be used per test. Site of failure should be reported. Statistical analysis should include survival analysis to give a prediction of the performance of the material, which can be related to the clinical situation. Bond strengths should be quoted either in Newtons or Megapascals. They concluded that equally valid arguments can be made for alternative methods of bond strength testing and the above suggestions has been made as they are relatively easy to carry out, minimize the specimen preparation and have been used widely and by confirming to one technique valid comparisons of attachments and materials can be easily made offering more guidance to the clinical orthodontist.

Fricker, (1994)[51] worked with glass ionomer cement and found the same rate of success in bonding brackets to enamel surfaces as he did with composite cements, When a dentine conditioner was applied on tooth for ten seconds, then rinsed, followed by lightly drying the tooth surfaces before bonding the brackets with the glass ionomer cement.

Silverman, Cohen et al (1995)[113] explained the use of a new light-cured, resin-reinforced glass ionomer, for bonding brackets and concluded that may well become the method of choice for bonding orthodontic brackets. The resin-reinforced glass ionomer powder contained finely ground fluoroalumino-silicate glass, while the liquid contained polyacrylic acid, water, monomer, and an activator. The resin component was actually a mixture of three monomers with 2-hydroxyethyl-methacrylate (HEMA) being the major constituent, and a camphorquinone photoinitiator. The HEMA provides for a sharp setting reaction of the material when exposed to visible light irradiation.

Sinha PK, Nanda RS, Ghosh J. (1995)[114] presented a indirect bonding technique with a thermal-cured, fluoride-releasing resin. He stated that this resin combined advantages of adequate clinical bond strength, placement accuracy, and ease of clean-up after bonding and debonding with the ability to release fluoride.

Wiltshire and Janse van Rensburg(1995)[129] evaluated fluoride release from two nonfluoride visible light-cured orthodontic adhesives, as well as two fluoride-containing visible light-cured orthodontic adhesives. They polymerized ten circular disks, with a volume of 56.57 mm^3 and a surface area of 0.94 cm^2 of each filled resin in a split-mold by light-curing for 40 seconds and placed in 1 ml distilled water in individual polyethylene bottles and maintained at 37° C in an incubator. The fluoride content of the solutions was determined once every 24 hours for 7 days, followed by once weekly for a month, and thereafter once monthly, until 85 weeks and concluded that both nonfluoride and fluoride-containing adhesives released fluoride, and the fluoride release of the adhesives was characterized by an initial burst of fluoride during the first day, followed by a gradual tapering down of fluoride release and the fluoride containing adhesives release fluoride over a long period of time and fluorapatite formation resulting from fluoride release from orthodontic adhesives reduced the decalcification during fixed orthodontic treatment. They explained that the release of fluoride from the nonfluoride adhesives could possibly be due to small amounts of fluorides such as barium fluoride, present in the inorganic phase of the adhesives.

Larry J. Oesterle.(1995)[92] conducted a study to determine whether increasing the curing time or the setting time increases the shear bond strength of a visible-light-cured orthodontic adhesive (Trans Bond XT). The results indicated that the shear bond strength was nearly 5kg on average for the samples exposed to 20 seconds of curing and allowed to set for two minutes. Extending the setting time to five minutes produced more than a 20% increase in bond strength. However, waiting 20 or 30 minutes resulted in only small additional increments of strength (7% and 8%, respectively). Strength after 24 hours is more than double that after two minutes and nearly 50% greater than after 30 minutes. They also concluded that increasing the curing time increases the shear bond strength.

Rashid Ahmed Chamda, Errol Stein (1996)[102] evaluated the bond strength achieved with a light-cured bonding system at selected time intervals over a 24-hour period and compared with the bond strengths produced by a chemically cured system over a similar period. The bond strengths for the chemically cured system were initially low, but these increased with time because of the continued polymerization of the resin under the bracket base. The light-cured sample displayed initial bond strengths of sufficient magnitude to withstand the immediate application of orthodontic forces, and these bond strengths also increased with time. . This increase was due either to a dual cure system in the formulation of the resin or to the polymerization of the resin under the bracket base after the diffusion of free radicals. The in vitro shear/peel bond strengths obtained with a light-cured resin at 2 minutes and 5 minutes after curing were significantly greater than those produced by a chemically cured resin at the similar time periods. There was no significant difference between the bond strengths achieved by the chemically cured and light-cured systems at the 10-minute, 60-minute, and 24-hour intervals.

E. Nkenke et al (1997),[88] conducted an experimental study to determine the tensile bond strength of stainless steel, ceramic and plastic brackets bonded to the bovine enamel using a conventional two-paste orthodontic bonding resin(Concise), a light-cured, fluoride-releasing adhesive (Sequence), a no-mix-orthodontic bonding resin(system I) and a light-curing glass ionomer cement (Photac Fil). For evaluation of the experimental data the Weibull analysis was applied.

Pramod K. Sinha, Ram.S. Nanda et al (1997)[100] stated that sustained fluoride-releasing composite resins have the potential to prevent decalcification of enamel that may occur during the course of orthodontic treatment. They evaluated the potential of two matrix-bound fluoride-releasing adhesives (MBF) for orthodontic use by comparing the shear bond strengths and remnant adhesive on debonding of these resins with commercially available five nonfluoride releasing orthodontic adhesives. They concluded that fluoride releasing light and self-cured orthodontic bonding adhesives have favourable bond strengths and ARI scores when compared with nonfluoride-releasing versions and fluoride-releasing orthodontic adhesives may prove to be clinically useful orthodontic bonding agents.

Agneta Marcusson et al (1997)[3] conducted study to test the benefit from using glass ionomer cement (AquaCem) instead of a conventional diacrylate (Unite) in bracket bonding for the prevention of white spot formation. They concluded that the use of a GIC for orthodontic bonding would result in a significant reduction in the number of white spot surfaces at debonding compared with the use of conventional diacrylate. Although markedly reduced in both groups, the number of affected surfaces was still higher 2 years after debonding than before treatment.

Ortendahl, B. Thilander, and M. Svanberg (1997)[119] investigated the levels of streptococcus mutans in plaque adjacent to orthodontic brackets retained with glass ionomer and a resin based composite after full term orthodontic treatment and found that the mean levels of these microorganisms were lower in plaque adjacent to glass ionomer retained brackets compared to composite retained brackets.

Samir E. Bishara et al (1998)[108] evaluated a new light-cured bonding system that used a hybrid adhesive containing a resin reinforced glass ionomer (Fuji Ortho LC,) and compared it with a more traditional light-cured bonding system (Transbond,) that contained resin material only. The shear bond strength was performed after thermal cycling between 5° ± 2° C and 50° ± 2° C for a total of 2000 cycles. They concluded that with etched enamel, even when contaminated with water or saliva before bonding, the newly introduced light-cured resin-reinforced glass ionomer adhesive system has comparable shear bond strength, as the traditional light-cured composite resin systems. . With unetched enamel, the shear bond strength of the resin-reinforced glass ionomer adhesive is significantly reduced by a third to a half. This reduction in bond strength is critical and should be taken into consideration by the clinician, because the residual bond strength might not be able to withstand the forces produced during routine clinical orthodontic procedures.

Stephen J. Lippitz et al(1998)[116] evaluated and compared the shear bond strengths of three resin-glass ionomer cements (Advance, Fuji Duet, Fuji Ortho LC) used as bracket adhesives with a composite resin 24 hours and 30 days after bonding. They concluded that the Resin-ionomer cements Advance, Fuji Duet, and Fuji Ortho LC had 24-hour and 30-day shear bond strengths that were statistically equivalent to those of the composite resin when used to bond mesh-backed stainless-steel brackets to the enamel surfaces of extracted human premolars and Resin-ionomer Fuji Ortho LC had 24-hour and 30-day shear bond strengths that were statistically lower in magnitude compared with the composite resin bonding adhesive when the enamel surfaces were not etched with polyacrylic acid.

Hugo R. Armas Galindo, Lionel Sadowsky,et al(1998)[62] conducted an invivo longitudinal clinical study to evaluate and compare the rate of success and/ or failure between a visible light-cured bonding material and a chemically cured bonding material using both systems in every patient by bonding contralateral quadrants with each system respectively. Results showed that the failure rate of the visible light-cured composite was 11.3% and that of the chemically cured composite was 12% with no statistically significant differences between the failure rates of the two systems.

Susan AI-Khateeb, Carl-Magnus Forsberg et al (1998)[117] stated that slow and gradual recovery of white spot lesions would have a beneficial effect on the quality of remineralization and would be favourable from an aesthetic point of view as well. During and after application of high concentration of fluoride, large amounts of fluoride are adsorbed in the lesion because of the great affinity of the demineralized regions to fluoride. As a result of this high fluoride concentration, mineral precipitation will be accelerated in the outermost region of the lesion; this process draws away many of the free mineral ions from the inner pores of the lesion and thus slows down diffusion toward the lesion interior. This will result in a delay of the remineralization of the lesion body. In addition, the excess deposition, also described as hyperremineralization, may cause the lesion pores to be blocked with mineral and result in a more pronounced diffusion inhibition.

Geurstsen W, Leyhausen G, Garcia – Godoy F. (1999)[55] measured the surface microhardness (Vickers) as well as the release of fluoride from four polyacid modified composite resins (Compoglass F, F 2000, Dyract AP, experimental compomer) after storage in various artificial saliva (buffers) including one esterase buffer. Concluded that the action of salivary esterase may weaken the surface of poly acid- modified composite resin restorations. As a clinical consequence, wear may be enhanced and load resistance may be reduced. In addition, fluoride release from polyacid modified composite resins may be increased by hydrolytic enzymes in saliva and under acidic conditions.

Itota T, Okamoto M, et al (1999)[63] investigated the release and recharge and rerelease of fluoride by restorative materials after exposed to topical fluoride solutions. Resin modified glass ionomers, polyacid modified composite resins and resin composite containing fluoride was used for comparison of fluoride release. Non-fluoride releasing composite resin was used as a control. The amount of fluoride released from the resin modified glass ionomers, polyacid modified composite resins remarkably increased in the citrate phosphate acid buffer compared with distilled water. The amount of fluoride recharged in resin modified glass ionomers increased with the concentration of NaF solution, but those of polyacid modified composite resins exposed to all concentrations of NaF solutions were less than 1.5 ppm. Neither resin composite containing fluoride nor the nonfluoride releasing resin composite gave any evidence of recharge. Resin modified glass ionomers, and polyacid modified composite resins affected by acid buffer solution could not recharge much fluoride even if they were immersed in the1000 ppm F NaF solution. The results suggested that the matrix of resin modified glass ionomers and polyacid modified composite resins functioned as a reservoir of fluoride, but the functions were lost as a result of acid attack.

Meehan .P.M et al (1999)[81] conducted a study to determine the in vitro shear bond strength (in megapascals) and location of bond failure with two light-cured glass ionomer resin systems (Fuji Ortho LC) and (Ultra Band Lok) and to compare them with a light-cured composite resin control (Transbond XT). They concluded that even though new generation of resin-modified GICs showed improved bond strength over conventional glass ionomer cement adhesives, they do not appear to provide sufficient shear bond strength. They suggested that the addition of a mechanical bond through enamel conditioning to the chemical bond might provide clinically acceptable bond strength.

Stephanie.E. Steckel, Frederick. A. Ruggerberg, Gray M. whitford (1999)[115] compared the three types of adhesives on enamel (No mix, chemically cured and light cured each with and without fluoride content). They observed that presence of fluoride in the bonding adhesive does not reduce the shear bond strength. Chemically and light cured system produce consistently higher bond strength when compared to the no mix product.

Bishara. E.S., Leigh Von Wald et al (2000)[16] conducted a study to determine the effects of increasing the light cure time on the initial shear bond strength (in the first half an hour) of a resin modified glass ionomer adhesive (Fuji Ortho LC). Results showed that the resin reinforced glass ionomer adhesive has a significantly lower bond strength in the first half an hour after bonding when compared to a conventional resin adhesive(Trans Bond XT) and the initial strength of the glass ionomer adhesive was significantly, increased by increasing the light cure time for an additional 5-10 seconds. The mean increase in shear bond strength between 5 and 10 seconds of additional light curing was not significant but the variability was less with the longer cure time.

Jeremy Knox et al (2000)[67] conducted a study to determine the resilience, glass transition temperature, ultimate flexural strength and penetration coefficient of three composite adhesives, [Concise, Transbond and Right on] and a glass ionomer cement [Fuji Ortho LC]. Results showed that 25 minutes after initial set, the composite materials were significantly more resilient than the resin modified glass ionomer cement. Resilience value for all materials increased for up to 90 minutes after initial set reflecting a continuation of their setting reaction. The glass transition temperature of resin modified glass ionomer cement was low, resulting in softening of the cement matrix and attachment failure at 50ºc - 60ºc. The flexural strength and penetration coefficient of the resin modified glass ionomer cement was less than that of the composite resins. The resin modified glass ionomer cement offered a reduced energy absorbing capacity immediately after bracket placement and reduced cohesive and mechanical adhesive strength.

Millett D.T. et al (2000)[32] studied the invivo survival time and cariostatic zotential of a compomer (Dyrect Orthodontic) and compared it with a composite resin bonding material (Right on). They concluded that the survival time distributions of brackets bonded with compomer or resin adhesive appear comparable but bonding with compomer reduced decalcification of enamel significantly.

Owens S.E. et al (2000)[98] evaluated the shear bond strength and site of bond failure for two visible light cured composites (Transbond XT and Enlight) and a resin modified glass ionomer cement (RMGIC; Fuji Ortho LC). Results showed that the shear bond strength of Fuji ortho LC was significantly lower than the shear bond strength of Enlight and the Transbond XT. The difference between shear bond strength of enlight and Transbond XT was not statistically significant. An evaluation of mode of failure revealed that the Enlight and Transbond XT specimens failed in similar manner. Both of them had few cohesive failures, but most were adhesive and mixed failures at both the enamel and bracket interfaces. The Fuji Ortho LC failed adhesively at the bracket interface almost exclusively. They concluded that if the bond strength is the primary consideration for choosing a bonding adhesive the composite resins are the adhesives of choice.

Yip. HK, Smales RJ. et al (2000)[133]Conducted a study to compare the fluoride ion release from a freshly mixed polyacid modified resin composite, or compomer (Dyract) and three resin modified glass ionomer cements (Fuji II LC, Photac-Fil, and Vitremer) and to compare the use of 3 units for measuring fluoride release.Fluoride measurements were carried out using a fluoride ion-selective electrode connected to a pH ion-selective electrode meter. Fluoride ion release was measured in parts per million, micrograms per square centimeter, and micrograms per cubic millimeter. Showed Fuji II LC, Photac-Fil, and Vitremer showed high initial release values which decreased exponentially and then showed a slow decline during the ensuing time. Dyract released significantly less fluoride ions during the first 84 days than did the three resin – modified glass ionomer cements and maintained this low level of release throughout the study period. The amounts of fluoride ion release measured at any time interval varied with the units of measurements chosen but the pattern of release remained the same. They concluded that there was a wide variation in the amounts of fluoride ions released from related products, but the patterns of release were similar and unaffected by the units of measurements used.

Alexander S.A. and Ripa L.W (2000)[4] conducted a study to compare the effectiveness of tooth brushing followed by fluoride rinsing, fluoride gel brushing, or fluoride gel dentifrice brushing alone in controlling the demineralization that follows orthodontic treatment and they concluded that the exposures to both low-potency, high-frequency fluoride preparations and high-potency, high-frequency fluoride preparations serve to prevent the appearance of moderate to severe demineralization in patients who undergo orthodontic therapy. Dentifrice and an over the counter rinse has a very good effect in preventing demineralization; however, high-concentration fluoride products produce a greater degree of protection. They also concluded that the reversal of white lesions at the end of active care occurred in 11% and 15% of patients who exhibited demineralization as early as 1 month into treatment and during the course of treatment, respectively.

Chun-hsi chung,et al (2000)[30] compared the clinical bond strength of an ion exchange fluoride releasing composite resin (Phase II) with that of the same composite without fluoride and showed that at one, three, and six months after bonding, there was no statistical difference in failure rates between the fluoride-releasing and the non-fluoride-releasing composites. Both of them had failure rates of less than 1% at one month, less than 2% at three months, and less than 5% at six months.

Doughlas Rix (2001)[36] conducted a study to evaluate and compare the fluoride release of a resin modified glass ionomer cement (Fuji Ortho LC, encapsulated) and a polyacid modified composite resin (Assure) with a nonfluoride releasing composite resin control (Transbond XT). Polyacid modified composite resin released more fluoride per day than other two materials for first three months. At the end of 150 day observation period the resin modified glass ionomer cement released almost three times as much daily fluoride as released by the poly acid modified composite resin. On bracketed teeth resin modified glass ionomer cement released 78% more accumulated fluoride that the poly acid modified composite resin during the twenty eight day observation. They concluded that the discrepancies in fluoride release from the orthodontic adhesives observed in this study depending on the timing of water changes and between sample disks and bracketed teeth suggest that evaluating fluoride release should be done with caution and using a bracketed tooth model should be considered.

Douglas Rix (2001)[37] conducted a study to compare 3 orthodontic adhesives in the areas of shear-peel bond strength, location of adhesive failure, and extent of enamel cracking before bonding and after debonding of orthodontic brackets. The adhesives included a composite resin control (Transbond XT), a resin-modified glass ionomer cement (Fuji Ortho LC encapsulated), and a polyacid-modified composite resin under dry and saliva-contaminated conditions (Assure).The study revealed that Transbond XT displayed significantly greater shear bond strength than Fuji Ortho LC and Assure, although the bond strengths for all the three adhesives were clinically acceptable. There was no significant difference in mean shear bond strengths between Assure-wet (saliva-contaminated) and Assure-dry (non-contaminated) protocols. Fuji Ortho LC bonded after enamel conditioning with 10% polyacrylic acid and Assure-wet tended to display adhesive failure at the enamel adhesive interface while Assure-dry and Transbond XT tended to display cohesive failure within the adhesive. The greatest frequencies for enamel fracture upon debonding occurred in the groups showing the highest bond strengths (Transbond XT and Fuji Ortho LC). The high frequency of prebonding enamel cracking (46.7% of zones) in this sample of 160 human premolars may be due to the extraction process and may contribute to high enamel fracture occurrence upon debonding.

Ewoldsen and Demkey (2001)[86] in a review of orthodontic cements and adhesives highlighted the physical and chemical characteristics of cements, resins, resin-modified Glass ionomer cements, Polyacid-modified composite resins, with emphasis on their clinical features, handling and physical characteristics.

George V. Newman et al (2001)[54] conducted a study to evaluate the mean shear bond strength of micro etched stainless steel brackets bonded with resin modified glass ionomer, composite resin adhesive and an experimental resin modified (Expt AF) glass ionomer adhesive system. The use of bonding agents and promoters to maximize bond strength also evaluated. Results showed that the newly formulated adhesive system that uses the resin modified hybrid glass ionomer cement (Expt AF), the adhesion promoter megabond produced the highest bond strength. Fuji ortho LC produced higher bond strength when tooth surfaces were etched with 10% poly acrylic acid before bonding. The site of bond failure was at enamel adhesive interface for Fuji ortho LC used without acid etching. The composite adhesive, Experimental resin reinforced glass ionomer cement with adhesion promoter failed at bracket adhesive interface. The failure mode of resin modified glass ionomer cement and Fuji ortho LC with Acid etching was primarily of cohesive in nature.

Karanika – Kouma A (2001)[68] conducted a study to examine the antibacterial activities of the bonding systems Syntac, EBS and Scotchbond 1, the polyacid-modified composite resins Hytac and Compoglass, and the composite resins Tetric, ZIOO and Scalp-it. Results showed all adhesives of the dentin bonding systems and the polyacid – modified composite resins exhibited various degrees of antibacterial activity against all of the test bacteria. On the contrary, composite resins did not affect bacterial growth. They concluded that use of dentin bonding systems and polyacid-modified composite resins may reduce the consequences of microleakage owing to their antibacterial properties.

Maria Francesca Sfondrini et al (2001)[74] conducted a study to evaluate the shear bond strengths of a composite resin (Transbond XT) and a resin-modified glass ionomer (Fuji Ortho LC) cured with 2 different light-curing units: a conventional visible light unit (Ortholux XT) and a xenon arc light unit (Plasma Arc Curing [PAC] System). Results showed that for the groups bonded with Transbond XT, no statistically significant differences were found between the shear bond strength of the control group cured with Ortholux XT and those of the groups cured with the PAC System for 2, 5, or 10 seconds. When the shear bond strengths of the groups bonded with Fuji Ortho LC were evaluated, no statistically significant differences were found between the control group that was cured with Ortholux XT and those cured with the PAC System. The bond strength of the composite resin was significantly higher than that of the resin-modified glass ionomer in all the groups tested . They concluded that compared with visible light-curing, the xenon arc light enables the clinician to significantly reduce the curing time of both bonding agents, without affecting their shear bond strengths and bond strength of the composite resin is significantly higher than that of the resin-modified glass ionomer under various bonding conditions evaluated in this study.

McNeil. J.C. et al (2001)[31] evaluated and compared the rates of fluoride release from one non-fluoridated (Transbond XT) and three fluoride releasing orthodontic bonding materials, two poly acid modified composite resins (Assure, Python) and a resin modified glass ionomer cement (Fuji Ortho LC) in distilled water and artificial saliva. Readings were taken periodically for a total time period of six months, with a combination ion specific electrode. The fluoride lends were higher during the first seven days of testing, decline to lower but more stable levels at the end of twenty two days. Although fluoride levels declined with time, they were still higher at the end of six months, 1.5 $\mu g/cm^2$ level that is adequate to inhibit decalcification of enamel in a clinical environment even though the poly acid modified composite resin released the highest amount of fluoride at the first day, the resin modified glass ionomer cement released the highest rate of fluoride at the end of six months.

Ogarrd B, Bishara.S. et al (2001)[97] conducted a randomized prospective clinical study, with 220 patients scheduled for fixed orthodontic therapy, to test the hypothesis that application of an antimicrobial varnish in combination with a fluoride varnish is significantly more efficient in reducing white spot lesions on the labial surfaces than application of the fluoride varnish alone and concluded that antimicrobial varnish significantly reduced the number of streptococci mutans in plaque during the first 48 weeks of treatment with fixed orthodontic treatment but not the incidence of white spot lesions. However the combination of the antimicrobial and fluoride varnishes more effectively reduced the increments of new lesions of the maxillary incisors, the area where they represent the largest esthetic problem. They also concluded that the best predictors for white spot lesions at debonding were visible plaque and streptococci mutans around the appliance shortly after bonding.

Arthur. W. Wheeler. et al (2002)[9] compared the fluoride release estimation protocols for in vitro testing using 3 orthodontic adhesives, a composite resin (Transbond XT), a resin modified glass ionomer cement (Fuji Ortho LC), and a poly acid modified glass ionomer cement (Assure). They concluded that daily solution change protocol should be used for fluoride release studies rather than cumulative solution change protocols. Either sample disks or bracketed teeth protocol can be used but the disk protocol may be preferred because of the longevity of accurately detectable fluoride release level

Bishara E.S. et al (2002)[109] conducted a study to evaluate the shear bond strength of orthodontic brackets bonded with composite resin after using a self etching primer containing fluoride. The self etching primer releasing 130 ppm/d during the first month, 50 ppm/d in the next two months, 20 ppm/d between 6 and 12 months and 10 ppm/d between one and two years. They concluded that the newly introduced self etch primers containing fluoride have adequate bond strength and can be successfully used in bonding orthodontic brackets.

Fredrick Bergstrand et al (2003)[49]evaluated seven studies from the systematic review conducted by the RTI/UNC evidence based practice center and concluded that combination of professional low frequency, high dose topical fluoride applications and a high frequency, low dose home care programs are required to facilitate renmineralization of the white spot lesions after debonding of fixed orthodontic appliances. They also suggested that randomized controlled trials to evaluate the efficacy of various methods of managing while spot lesions related to orthodontic treatment.

Jasmine Gorton, and John D. B. Featherstone (2003)[65] conducted a study to test the hypothesis that fluoride released by glass ionomer cement inhibits the formation of carious lesions around orthodontic brackets in vivo. Brackets were bonded on 2 first premolars in 21 randomized, consecutively selected patients 11 to 18 years old. Eleven test-group subjects were bonded with fluoride-releasing glass ionomer cement (Fuji Ortho LC), and 10 control subjects were bonded with a conventional composite resin control(Transbond XT), The teeth were extracted after 4 weeks, sectioned, and evaluated quantitatively by cross-sectional micro hardness testing. Fluoride levels in patients saliva were measured by the Taves diffusion method in samples taken at days 0 (baseline), 1,2,3,7,14,21 and 28 to determine whether fluoride from the glass ionomer cement influenced the overall intraoral fluoride levels. The results demonstrated significantly more demineralization around the brackets of the control patients. For whole-mouth salivary fluoride levels, no significant overall difference between the group and no noticeable trend within group were found. They concluded that using fluoride-releasing glass ionomer cement for bonding orthodontic brackets successfully inhibited caries in vivo. This cariostatic effect was localized to the area around the brackets and was statistically significant after 4 weeks.

Manuel Toledano et al (2003)[73]conducted a study to evaluate the shear bond strength of stainless steel orthodontic brackets directly bonded using a chemically cured composite resin (System one), a light cured composite resin (Light bond), a self curing glass ionomer (Viva glass cem) cement, a resin modified glass ionomer cement (Fuji ortho LC) after acid etching and without acid etching. Results showed that the chemically cured composite resin achieved the highest bond strength followed by the light cure adhesive and resin reinforced glass ionomer cement used after acid etching. They concluded that for direct bonding of orthodontic brackets acid etching with 37% orthophosphoric acid is strongly recommended with resin modified glass ionomer cements. Obtained bond strengths are within the range of clinical use and are not different from that of conventional light cured composite material when resin modified glass ionomer cement and the self cure glass ionomer cement was used with acid etching. When resin modified glass ionomer cement and the self cure glass ionomer cement was used without acid etching the shear bond strength was low below the range of clinical use.

Warren J. cohen et al (2003)[126] conducted a study to compare in vitro long-term (30 month) fluoride release and rerelease rates, after fluoride exposure from three orthodontic bonding materials containing fluoride (Python, TP Orthodontics, LaPorte, Ind; Assure, Reliance Orthodontic Products, Itasca, III; Fuji Ortho LC GC America, Alsip, III;) and 1 without fluoride (Transbond XT, 3M Unitex, Monrovia, Calif). Ten samples of each material were fabricated and stored in deionized distilled water at 37ºc. Five samples had fluoride- release rates measured at days 546, 637, 730, 821 and 913 after initial fabrication, and 5 samples were exposed to fluoride (Nupro 2% NaF gel, Dentsply Canada, Woodbridge, Ontario, Canada) for 4 minutes at day 535 and had measurements taken on days 546, 548, 552, 575, 637, 730, 821, and 913. To prevent cumulative measurements, the storage solutions were changed 24 hours before measurement. Statistically significant differences were found in fluoride-release rates with Fuji Ortho LC releasing the most fluoride. A “burst-effect” pattern of fluoride release was seen after fluoride exposure for all materials. They concluded that Fuji Ortho LC, Assure, and Python might have sufficient long-term fluoride-release rates to reduce white spot formation, and all are recommended as suitable fluoride-releasing orthodontic bonding materials

Dionysopoulos et al (2003)[35] Conducted a study to assess the capacity of fluoride-releasing restorative materials to resist caries in vitro. Three polyacid modified resin composite filling material (F –2000, Hytac and compoglass F). a resin Modified glass – Ionomer cement (Fuji II LC) a conventional glass ionomer (Ketac-Fill). and a resin composite (Z-100). The results showed that restoration of caries with polyacid modified resin composites and resin modified glass ionomer cements may be of great importance in the prevention of secondary caries around the restorations in roots. They concluded that light cured fluoride – releasing restorations may inhibit caries like lesions.

Andrew summers et al (2004)[6] conducted a study to compare the invivo survival rates of orthodontic brackets bonded with a resin reinforced glass ionomer (Fuji Ortho LC,) after conditioning with 10% polyacrylic acid and a conventional resin adhesive (light bond) bonded after etching with 37% phosphoric acid and the invitro shear bond strength, mode of bracket failure and adhesive remnant index of the two adhesives. Results showed greater invitro shear bond strength of orthodontic brackets bonded with conventional resin adhesive (Light bond) bonded after etching with 37% phosphoric acid compared with resin reinforced glass ionomer (Fuji Ortho LC,) after conditioning with 10% polyacrylic acid. Significantly greater bond strengths were obtained 24 hours after bonding for both the materials. Invivo results showed that the difference between the survival rates of the two adhesives was not statistically significant. The predominant bracket failure interface for Fuji Ortho LC was at the enamel adhesive interface making the enamel clean up procedures easy for the clinicians.

Philip.E.Benson(2004)[99] conducted an invivo study to investigate the effect of fluoridated elastomeric ligatures on the microbiology of local dental plaque. They conducted that fluoridated elastomers are not effective at reducing streptococcal or anaerobic bacterial growth in local plaque surrounding an orthodontic bracket after a mean time of 40 days in the mouth. Oral Hygienic instructions for patients is likely to be more effective at reducing local plaque.

Todd kimura et al (2004)[122] conducted a study to investigate the relationship between the shear bond strength and of orthodontic brackets to enamel, with or without fluoride varnish, by using either conventional or self etching primer system. They concluded that no difference existed between shear bond strength and Adhsive Remanant index of orthodontic brackets bonded to enamel, with or without fluoride varnish, by using either conventional or self etching primer system. Most of the adhesive remained on the etched tooth enamel surface.

RESULTS

FLUORIDE RELEASE OF ADHESIVE DISK SAMPLES

The mean fluoride release rate for all the three adhesive samples (Python, Transbond XT and Fuji Ortho LC) in distilled water and artificial saliva at day 1,2,3,4,5,6,7,14,21,and 30 are shown in the Table 1.

Fuji Ortho LC released the maximum amount of fluoride throughout the study both in distilled water and artificial saliva, followed by Python and Transbond XT.

Statistically significant difference was present among the mean fluoride release of all the three adhesive disk samples at day 1, day 7, and day 30 both in distilled water and artificial saliva. (table 2 and table3).

Fuji Ortho LC and Python released more amount of fluoride in distilled water than in artificial saliva at day 1, day 7 and day 30. The exception being Python, statistically significant difference was not found between the mean fluoride release of Python into distilled water and artificial saliva to Day 30. The amount of fluoride released by Transbond XT into artificial saliva and distilled water were not significantly different throughout the study. (table 4 , table 5 and table 6)

The pattern of fluoride release of Python and Fuji Ortho LC in both the storage medium was similar, with both the materials initially showing higher rate of release but declining to a low but more stable levels with time. The exception was Transbond XT, which released very low but constant amount of fluoride through out the study. (table 8)

The mean fluoride release of Python and Fuji Ortho LC at day 1 and day 30 in both the storage medium were significantly different, the maximum amount of fluoride being released on day 1 for both the materials. (table7 and table 9).

SHEAR BOND STRENGTH

The descriptive statistics including mean shear bond strength, standard deviation, standard error, maximum and minimum value for all the six groups are shown in the table 10. The mean shear bond strength of all the six groups is depicted in the graph 1.

Transbond XT showed the maximum mean shear bond strength at 30 min (6.541 Mpa) and 24 hours (12.514 Mpa), followed by Python (5.139 Mpa, 10.361 Mpa) and Fuji Ortho LC (2.478 Mpa, 6.276 Mpa).

Statistical analysis of the mean shear bond strength of the three adhesives at 30 minutes using analysis of variance and Tuckey HSD test showed significant difference between the three groups tested. (table 11 and table 12).

Statistical analysis of the mean shear bond strength of the three adhesives at 24 hours using analysis of variance showed significant difference between the groups (table 13). Tuckey HSD test showed that the mean shear bond strength of Transbond XT and Python at 24 hours were not significantly different from each other (table 14).

Student's independent –t test showed that the mean shear bond strength of all the three adhesives at 24 hours were significantly greater than the mean shear bond strength at 30 min. (table 15).

Table 16 shows the weibull modulus for the three materials tested. The highest weibull modulus of 3.83 was recorded with Transbond XT indicating the greatest bond reliability, followed by Python light cure adhesive (3.593). The highest characteristic strength of 13.858 Mpa was recorded with Transbond XT indicating the greatest bond strength, followed by Python light cure adhesive (11.492 Mpa). The reliability of the material is a function of weibull modulus and the characteristic strength. The probability of bond failure to applied shear stress for the three light cure adhesive materials are graphically represented in the graph 2, graph 3 and graph 4

ADHESIVE REMNANT INDEX

The adhesive remnant index of each sample group in each group are shown in table 18 and graph 5. The results of Chi-square test showed that there is a significant association between the ARI score and different groups. (table 18). The Spearmen rank correction analysis between the bond strength and ARI scores shows a significant relationship between bond strength and ARI score in all the groups. (table 19).

DISCUSSION

Decalcification of enamel can occur within 4 weeks of initiating orthodontic treatment [90,94]. Gorelik et al reported white spot lesions on 3.6% of the teeth in an untreated sample compared to 10.8% of teeth at debonding in orthodontically treated patient sample[56]. Fluoride rinse programs have been shown to significantly reduce the occurrence of white spot lesions, during orthodontic treatment[53,96]. Geiger et al found that 50% of the patients cooperated poorly with fluoride programs despite a concentrated effort to educate and motivate them[53]. This dependence on compliance may be reduced by using an adhesive that releases sufficient amount of fluoride to prevent decalcification.

Glass Ionomer cements have been shown to release fluoride over a long term at higher levels that are sufficient to reduce the incidence of decalcification in patients treated with fixed orthodontic appliances[45]. The poor bond strength and greater failure rate of glass ionomer cements have limited their use as an orthodontic bonding material[43].

Addition of resin monomers to the polycarboxylic acid solution of glass ionomer cement resulted in Resin Modified Glass Ionomer Cements (RMGIC). Polymerization of resin monomers hastens the initial settings of Resin Modified Glass Ionomer without significantly affecting the acid base setting reaction, fluoride release or chelation of carboxyl groups to the metal and tooth surfaces[86].

Polyacid modified composite resins are single component systems consisting of aluminosilicate glass in the presence of carboxyl modified resin monomer and light activated conventional resin monomers. Although alkaline glass and acidic carboxyl components are present in a single composite paste, acid base reaction do not occur because of absence of water in the composition. However after light activation it is postulated that water absorbs into the compomer from the oral cavity, allowing a delayed acid base setting reaction, that release fluoride, from the aluminosilicate glass. McLean has suggested the term Polyacid modified composite resins for materials containing either or both essential components of glass ionomer cements but at a insufficient amount to produce acid base reaction in the dark[79].

The absence of hydrogels in the set matrix of compomers restricts ion uptake and ion release from the set matrix of compomers, yet fluoride recharging of compomers has been reported and can be explained by water sorption and diffusion dynamics. Carboxyl chelation with cations on enamel, dentin and metallic surfaces has not been shown to occur with compomer resins. Acid etching and dry enamel surface are prerequisite before bonding. The early setting strength of Polyacid modified composite resins, are superior to those of Resin Modified Glass Ionomer Cements but inferior to those of resin adhesives[2]. The amount of fluoride released from the Polyacid modified composite resins is reported to be significantly less than those of Resin Modified Glass Ionomer Cements[36].

However a sustained amount of fluoride release over an extended period of time, that is sufficient enough to present decalcification of enamel surface around orthodontic brackets have been reported with polyacid modified composite resins [36] .

In this present study the Resin Modified Glass Ionomer Cement (Fuji Ortho LC) released the highest amount of fluoride both in distilled water and artificial saliva through out the study period. The fluoride release rate of Fuji Ortho LC was maximum at day 1 in distilled water ($25.57 \pm 2.39\ \mu g/cm^2$). The release rate subsequently dropped to a lower level after one week and had reached a near constant level at day 30. The polyacid modified composite resin (Python) released maximum amount of fluoride on day 1 in distilled water ($7.24 \pm 0.57\ \mu g/cm^2$). The amount of fluoride released by the Python both in distilled water and artificial saliva were significantly less than the amount of fluoride released by Fuji Ortho LC throughout the study period. **Cynthia J. Mc Neil et al** [31] reported similar findings. The greater amount of fluoride released by the Fuji Ortho LC can be explained by the presence of higher concentration of aluminosilicate glass in the powder of glass ionomer cement which releases fluoride during the setting reaction[86].

The pattern of fluoride release of Python and Fuji Ortho LC in both the storage medium was similar, with both the materials initially showing higher rate of release but declining to a low but more stable levels with time. The exception was Transbond XT, which released very low but constant amount of fluoride through out the study.

Transbond XT, which is a conventional composite resin, showed a consistently low rate of fluoride release both in artificial salvia and distilled water throughout the study period. The small quantity of measurable fluoride in a non fluoride composite is due to the presence of small amounts of fluoride containing glasses in the dispersed inorganic phase of the composite material [44,45] or may be due to the presence of a constant amount of fluoride in the distilled water[132] or due to the TISAB in the test solution that frees the fluoride bound to the hydrogen and is recorded by the fluoride specific electrode[31].

The fluoride released from the Fuji Ortho LC and Python light cure adhesive was significantly lower in artificial saliva than it was in distilled water. Other researchers have also found fluoride release to be lower in artificial saliva. Chemical components from the artificial saliva [31,40], such as calcium, carbonate, hydrogen, phosphate and sodium may react with fluoride or be adsorbed by the cement thereby potentially acting as a barrier to reduce initial solubility[125].

Both the Resin Modified Glass Ionomer Cement and Poly acid modified composite resin had an initial high burst of fluoride release during the first few days[24,129,134]. This initial burst of fluoride release has been noted in many previous studies. An initial high amount of fluoride may be beneficial in remineralizing the etched enamel, through the formation of calcium fluoride reservoir on etched enamel.

The salivary concentration of fluoride is approximately 20µg/lr or 0.02ppm[33]. The volume of saliva secreted is approximately 570ml/day[127] giving a total amount of 11.4µg of fluorine into saliva[31] . If the results from the present study could be theoretically applied to the clinical situation, an estimate of the amount of adhesive exposed at the bracket base periphery would be 0.28cm^2 assuming an excess strip of 0.1mm wide of cement is present around the bracket base although this area of adhesive will depend on the size of the bracket and degree of care in removing excess adhesive[31]. This amount of adhesive with an estimated daily release of 1.45µg/ cm^2 of fluoride (amount of fluoride released by Python at day 30) will release 0.408µg per bracket. In a patient with 20 bracketed teeth the daily amount of fluoride entering the mouth from the adhesive will be theoretically equal to 8.12µg. Whether this release translates into a better protection against decalcification of surface enamel adjacent to orthodontic brackets can be determined only through clinical research.

Very low levels of fluoride may be enough to protect the sound enamel against demineralization. Decalcification was inhibited in enamel adjacent to a resin releasing as little as 1.5μg /cm^2/day[104]. An adhesive releasing fluoride at a rate of 0.5 – 1.0μg/cm^2/d reduced demineralization by 31% over 38 days in rats on a cariogenic diet[38]. Both the fluoride releasing adhesives estimated in this study released sustained rates of fluoride above this level.

Fluoride releasing materials have shown the potential to reimbibe and release fluoride after exposure to topical fluoride treatments[104]. Fluoride release and prerelease data on orthodontic bonding materials should be gathered for longer than 2 years, under running water or artificial saliva to simulate the salivary flow, with intermittent exposure to topical fluoride to simulate clinical conditions.

The shear peal bond strength of all the three bonding agents were measured at 30 minutes and at 24 hours[6]. This was designed to simulate a clinical situation, because arch wires are placed at the bonding appointment, when the light cure materials might not have been completely polymerized[51].

The mean shear bond strength of all the three adhesive materials evaluated in this present study was significantly higher at 24 hours than at 30 minutes. This result agrees with the findings of **Bishara et al** [16] and **Andrew summers et al**[6] and is probably related to the incomplete polymerization of the light cured materials at 30 minutes.

The initial mean shear bond strength of the poly acid modified composite resin, Python (5.319 Mpa) was significantly greater than that of the resin modified glass ionomer cement, Fuji Ortho LC (2.478 Mpa) but inferior to those of the conventional composite resin, Transbond XT (6.541 Mpa) as shown by various studies.

The final mean shear bond strength of the poly acid modified composite resin, Python (10.361 Mpa) was significantly greater than that of the resin modified glass ionomer cement, Fuji Ortho LC (6,276 Mpa) but was not significantly different from conventional composite resin, Transbond XT (12.514Mpa). The reduced bond strength of the resin modified glass ionomer cement, may be due to the fact that the material was used on unetched enamel, and the chemical bond between the glass ionomer adhesive is weaker than the mechanical bond produced by the resin adhesives in etched enamel.

All the adhesives tested in this investigation produced shear bond strength greater and within the range of 5.9 to 7.8 Mpa considered by **Reynolds** [106] to be adequate for routine clinical uses, except the initial bond strength of resin modified glass ionomer cement.

Transbond XT had the highest characteristic bond strength and greater bond reliability as shown by the weibull modulus [46,48,75,88] followed by the Python light cure adhesive.

In this present study the predominant mode of bracket failure for Python light cure adhesive was cohesive in nature both at adhesive bracket interface and at adhesive enamel interface. The predominant mode of failure for Transbond XT was adhesive in nature at the adhesive bracket interface leaving adhesive on the tooth surface. This is probably because of the incomplete polymerization of resin below the bracket base[117]. Air entrapment behind the mesh of bracket can also affect polymerization, because of the oxygen inhibition of free radical polymerizing in light cure composite materials[72]. The bond strength of the adhesive to the acid etched enamel surface is greater than the bond strength of the composite resin to the bracket base.

The predominant mode of failure for Fuji Ortho LC was at the enamel adhesive interface. This suggest that the chemical and mechanical bonding of glass ionomer cement to the bracket base is stronger than the chemical bond of glass ionomer to unetched enamel surface, even in the presence of resin component. This agrees with the results reported by **Mc sherry**[80], that the resin modified glass ionomers bond better to the metal base of the bracket than to the enamel. This mode of failure in RMGIC makes enamel clean up easy after debonding.

SUMMARY AND CONCLUSION

The use of composite resins for direct bonding of orthodontic brackets has become a routine procedure in present day orthodontics. Despite several advantages of direct bonding systems, the development of enamel decalcification around bonded orthodontic appliances continues to be a great clinical concern. Several fluoride-releasing materials have been introduced as orthodontic bonding materials including glass ionomer cements, resin modified glass ionomer cement and poly acid modified composite resin in an attempt to minimize the incidence of decalcification around the orthodontic appliance.

The present study was designed to evaluate the amount of fluoride release and the shear bond strength of a polyacid modified composite resin (Python light cure material) and to compare it with a resin modified Glass Ionomer cement (Fuji Ortho LC) and a conventional composite resin material (Transbond XT).

The following conclusions were drawn from the results of the study

1. The amount of fluoride released by the poly acid modified composite resin (Python) is significantly less than the amount of fluoride released by the resin modified glass ionomer cement (Fuji Ortho LC) , and significantly higher than the amount of fluoride released by conventional composite resin material (Transbond XT) in distilled water and artificial saliva

through out the study period.

2. The type of storage medium created a significant difference in fluoride release for the resin modified glass ionomer cement (Fuji Ortho LC) through out the study period and for the poly acid modified composite resin (Python) at day 1 and 7.Both of them released more amount of fluorine in distilled water. At day 30, the type of storage medium did not created a significant difference in fluoride release for Python.

3. Although the fluoride release later declined with time, the amount of fluoride released by the poly acid modified composite resin (Python) and the resin modified glass ionomer cement (Fuji Ortho LC) were above the proposed effective range of 0.63 – 1.23 $\mu g/cm^2/d$ for inhibition of enamel demineralization.

4. The mean shear bond strength of the all the three adhesives tested was significantly higher at 24 hours than at 30 minutes.

5. The final (24 hours) bond strength of Python light cure adhesive was significantly greater than the final (24 hours) bond strength of the resin modified glass ionomer cement (Fuji Ortho LC), but was not significantly different from that of the conventional composite resin, (Transbond XT).

6. The highest weibull modulus of 3.83 was recorded with Transbond XT indicating the greatest bond reliability, followed by Python light cure

adhesive. The highest characteristic strength was recorded with Transbond XT indicating the higher bond strength of the adhesive system followed by Python light cure adhesive.

7. All the adhesives tested in this investigation produced shear bond strength greater and within the range of 5.9 to 7.8 Mpa considered in the literature to be adequate for routine clinical uses, except the initial bond strength of resin modified glass ionomer cement.

8. The mode of bond failure for Python was adhesive or cohesive failure at bracket adhesive interface. The predominant bond failure of Transbond XT was more of adhesive bond failure at bracket adhesive interface. The predominant mode of bond failure of Resin modified Glass Ionomer cement was more of adhesive bond failure at bracket enamel interface.

9. There is a significant correlation between the adhesive remnant index and the bond strength for all the six groups.

Fluoride releasing adhesives have shown the potential to absorb and re-release fluoride after exposure to topical fluoride treatment. Further, leaching of fluoride ions from the resin matrix may weaken the bond strength of the material. The present study has evaluated only the fluoride release of the adhesive materials for a period of 30 days only and the bond strength of the materials at 30 min and 24 hours. The study on fluoride release and re-release of the orthodontic bonding materials should be done for a longer period of time to determine the amount of fluoride release throughout the estimated treatment period. The studies should be carried out in samples kept under running water or artificial saliva provided by a digital flow controller, with intermittent exposure to fluoride, to simulate the clinical condition. The bond strength should be evaluated at monthly intervals to determine the effect of fluoride release on the shear bond strength of the material.

Clinical trials are recommended to evaluate the bond survival rate and potency of these poly acid modified composite material to prevent decalcification of the enamel.

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